THE ANIMALS ASSOCIATED WITH EDIBLE FUNGI[1]

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During the course of several years' investigation of the biology and control of the insects and mites affecting cultivated mushrooms, the writer has observed and collected a large number of insects and related animals from manure piles and from the interior of mushroom houses. Of course all these have not been species which are injurious to the mushrooms, as many were merely transported into the houses with the manure. Some of the species, however, are undoubtedly potential mushroom pests, since they have been found feeding on wild mushrooms and other fungi outdoors.

The following annotated list shows not only those species which the writer has found, but also those identified and recorded by mushroom insect research workers throughout the world. Noteworthy among the latter should be mentioned the work of Austin, Jary, Pitcher and Stapley in England; of Ripper in Austria, and of Okada in Japan, while in the United States, Compton, Davis, Gahm and Popenoe have been the principal contributors to our knowledge of the fauna of cultivated mushrooms. Weiss has written a number of interesting papers on the insects inhabiting various fungi, but has not confined his observations to those fungi which are edible. The present paper deals almost exclusively with those animals affecting fungi which are used as human food, whether wild or cultivated artificially.

In the United States and in England the chief cultivated mushroom is the common Field Mushroom, *Psalliota* (*Agaricus*) *campestris* (L.) Fr. In Japan, however, the principal edible species are the "Matsutake," *Armillaria edodes* Berk., and the "Shiitake," *Cortinellus shiitake* P. Henn., the first of which grows wild about pine trees, while the second is artificially grown on oak logs. Another, small brown mushroom called

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"Nameko," *Pholiota nameko* (T. Ito) S. Ito & Imai, is also raised, largely for canning and exporting. While *Psalliota campestris* raising has developed rapidly in the past few years, most of them are canned and exported, some even coming to the United States. Okada's papers describe the principal insects affecting these fungi in Japan. Other fungi growing wild, and consumed by humans in various countries, are Morels (*Morchella* spp.), Puffballs (*Calvatia* spp.), Ink Caps (*Coprinus* spp.), *Russula* spp., *Lepiota* spp., and the Truffles of Europe, and many others, all infested by numerous insects which might feed on cultivated mushrooms.

As noted above, insects and mites may enter the mushroom houses in a variety of ways. Some of the mites, as the tyroglyphids and gamasids may come to the composting ground in manure on cars from the stables. Other mites, and most of the springtails, begin to enter the manure soon after it is piled on the ground, and gradually increase in numbers there. In the United States many adult phorids are found in and about these compost piles, while generally the adult sciarid flies are much less common there. Austin and Jary have found the same conditions to be true in England. Yet, in the United States, the sciarids are normally the most destructive mushroom pests. Some of the adults and larvæ undoubtedly enter the houses with the manure, but many are also attracted into the houses from adjacent infested houses and manure piles by the odor of the growing mycelium.

In addition to the direct injury to the mycelium and the growing mushrooms by these pests, it has been shown by Charles and Popenoe ('28) that the flies may transport mold spores on their bodies. The hypopial stage of the tyroglyphid mites is also frequently spread throughout mushroom houses by becoming attached to the bodies of flies, beetles, gamasid mites, etc. The present list contains not only those species which actually feed on some stage of the fungi, but also the predators and parasites which feed on these injurious species.

Appended is a bibliography listing practically all the papers concerning mushroom insects, except economic papers, which latter may be found in "Mushroom Insects, their Biology and

Control,'' Bulletin 270 of the Pennsylvania State College Agricultural Experiment Station, 1931.

The late C. H. Popenoe, during his work on mushroom insects for the United States Bureau of Entomology, collected a large number of species of mushroom insects, some of which are undoubtedly not listed in this paper. His specimens are now scattered through the U. S. National Museum collections.

The writer is greatly indebted to the following for specimen identifications and other courtesies: To the late Dr. J. W. Folsom, U. S. Bureau of Entomology, and Mr. Charles MacNamara, Arnprior, Canada, for the identification of numerous springtails; Dr. H. E. Ewing, U. S. National Museum, mites; Dr. O. A. Johannsen, Cornell University, sciarid flies; Dr. J. R. Malloch, U. S. National Museum, phorid flies; and Dr. E. P. Felt, Bartlett Research Laboratories, cecidomyiids.

NEMATHELMINTHES

Nematoda

Rhabdites teres Schnr.—Eelworm, Nematode—Austin 1933b, '34; Austin & Jary '34.

''Found just below the epidermis of the mushroom cap, where there was a marked breakdown and discoloration of the tissues. May be secondary.''

R. lambdiensis Maupas—Thomas '31; Steiner '33; Haseman & Ezell '34; Gahm '32a, '35; Davis '35a.

According to Steiner, this nematode is an agent in the spread of *Bacterium* (*Pseudomonas*) *tolaasi* Paine, the cause of a spot disease of mushrooms. Haseman and Ezell give an account of this pest and methods for its control.

MOLLUSCA

Limax maximus L.—Spotted Garden Slug—Falconer 1897; Busck 1902; Duggar '04; Popenoe '12, '17, '25; White '18; Symes & Chorley '21; Stewart '26, '27; Thomas '31; Davis '35a.

Occasionally found in mushroom houses, but not a common pest.

ARTHROPODA

Crustacea

Armadillidium vulgare Latr.—Greenhouse Pillbug—Falconer '97; Duggar '04; Popenoe '12, '17, '25; Symes & Chorley '21; Ripper '30; Gahm '32a, '35; Davis '35a (undetermined sp.).

Porcellio lævis Koch—Dooryard Sowbug—Popenoe '12, '17, '25; Ripper '30; Thomas '31; Gahm '32a, '35; Jary '34.

P. scaber Latr.—Symes & Chorley '21; Ripper '30; Jary '34.

Oniscus asellus L.—Sowbug—Symes & Chorley '21; Ripper '30; Austin '33b, '34; Jary '34.

According to Austin, "sowbugs in England feed on mycelium and eat holes in the mushrooms, and are sometimes abundant in the beds, especially in brick buildings." Although common in mushroom houses in the United States, they are usually not so injurious here.

Sowbugs, undetermined species—Güssow & Odell '27.

Diplopoda

Blaniulus guttulatus Bosc.—Millipede—Austin '33b.

Choneiulus palmatus Němec—Rolfe '34; Jary & Austin '35.

The above two species ate holes in mushroom caps and stems.

Cylindroiulus britannicus Verh.—Jary & Austin '37.

Mushrooms in England were heavily infested with this millipede.

Nopoiulus pulchellus Leach, *Brachyiulus pusillus* Leach, and *Chromatoiulus unilineatus* Koch were recorded by Ripper '30.

Symphyla

Scutigerella immaculata Newp.—Symphilid; Greenhouse or Garden Centipede—Parks '30.

Parks recorded this centipede as injuring mushrooms in Ohio. This seems to be the only record of it as a mushroom pest.

Centipedes (unnamed)—Noted as predatory on *Tyroglyphus mycophagus* in England—Symes & Chorley '21.

ARACHNIDA

Acarina: Mites

Eupodidæ

Linopodes antennæpes Banks (*motatorius* L.)—Gahm '30b, '30bb, '30c, '32a, b, '35; Thomas '31, '34; Compton '33, '35; Davis '35a; Ripper '30, '31; Austin '37; A. & Jary '37.

These long-legged mites sometimes cause much injury by feeding on the bottom of the mushroom stems, causing them to become reddish and constricted, and stopping their growth. They are apparently quite local in distribution. According to Austin, in England this species is often present, but apparently not abundant, in mushroom houses. Ripper states that it attacks *Coprinus atramentarius* as well as *Agaricus campestris.*

Eupodes sp.—Davis '35.

"Abundant in mushroom gills, Pomeroy, Pa."

Bdellidæ

Undetermined species are predacious on springtails—Thomas '31.

Tarsonemidæ

Tarsonemus sp. (possibly *T. floricolus* C. & F., according to H. E. Ewing)—Miller '25; Puntoni '31; Davis '36.

Determined in 1936 as causing injury to mushroom caps and stems in Pennsylvania, turning the external tissues rusty brown, much in the manner of *Linopodes.* Found in the vicinity of Kennett Square and Oxford, Chester County, Pa. Puntoni found a *Tarsonemus* species (probably *T. floricolus* variety) infesting fungus cultures in Rome. Miller noted mushrooms among the food materials infested by Tarsonemid mites.

Pigmeophorus americanus Banks—Davis '35; Thomas.

Davis stated that these mites attacked the spawn in his cultures. This species has been abundant in certain mushroom houses in the Kennett Square, Pa., area in 1936–37. It did not seem to injure the mushrooms, but fed on the mycelium under the casing soil.

Tyroglyphidæ

Tyroglyphus lintneri Osborn—Osborn 1893 (original description); Lintner '94; Busck '02; Popenoe '12, '17, '25; Banks '06, '15; Weiss '15; Thomas '26, '29, '31, '34; Caesar '27; Ripper '30; Gahm '30a, b. '32c, '35; Stapel '32; Compton '33, '35; Davis & Young '34, '35; Davis & Claborn '35; Davis '35a; McCarthy '36; Swan '37.

These tiny mites feed on the spawn pieces, the growing mycelium, and make holes in the caps and stems. These holes are moist and dirty. Hypopi of the various Tyroglyphid species are frequently carried on the legs of the Sciarid and Phorid flies and on the Gamasid mites, thus being spread from house to house. The injury to mushrooms is not common in Pennsylvania.

Tyroglyphus longior Gerv. (*Tyrophagus putrescentiæ* Schr.)—Davis '37.

All specimens taken by Davis on cultivated mushrooms in Washington, Illinois and Pennsylvania were a species identical with *T. longior,* rather than *T. lintneri,* the species usually recorded.

T. dimidiatus Herm. (*Tyrophagus putrescentiæ* Schr. and var. *castellani* Hirst)

Previously known only from copra fibre, caused injury to mushrooms in England in 1937, according to Jary and Austin '38. Speyer '37 stated that this mite (= *longior* Gerv.) caused typical injury to mushrooms in Worthing. Jary and Stapley '37 described all stages of this mite, and Jary '37 gave the characters differentiating *T. dimidiatus* and its variety *castellani.*

T. mycophagus Megnin—Symes & Chorley '21; Austin '33b; Jary '34; Austin & Jary '34; Bul. 34, Min. Agric. & Fisheries.

Common, injuring mushrooms in England. Symes and Chorley state that it has been known to ruin mushroom beds, particularly those protected by straw.

T. (*Aleurobius*) *farinæ* DeG. and *Glyciphagus cadaverum* are sometimes serious pests of fungus cultures, according to Jewson and Tattersfield '22. Austin '37 found this species associated with compost but not with the growing crop.

Rhizoglyphus phylloxeræ Riley—Banks '06; Gahm '30b, '35; Thomas '31, '34; Stapel '32; Davis '35a.

Occasionally found feeding in the spawn pieces in the beds.

R. spinitarsus—Symes & Chorley '21.

Reported as destroying mushrooms in a cave at Reigate.

Cosmoglyphus (*Caloglyphus*) *krameri* Berl.—Austin & Jary '34, '35; Jary & Austin '35.

The most common and destructive mushroom mite in England. May ruin the mushrooms as well as the mycelium.

Histiostoma (*Chortoglyphus*) *gracilipes* Banks—Banks '06; Gahm; Compton '33, '35; Thomas '34; Davis & Young '34, '35; Davis '35a; Davis & Claborn '35.

This mite feeds on the mycelium in the beds and on the growing mushrooms, especially on those somewhat injured. Compton states that this mite is very destructive in Illinois, causing more damage to mushrooms than do the *Linopodes* or *Tyroglyphus* mites. The hypopi of this species sometimes pile up in immense numbers on the casing soil and mushrooms, and are then easily spread by flies. Such piles are light reddish brown in color. The hypopi are not very active.

H. rostroserratum Megnin—Lintner '94; Symes & Chorley '21; Jary & Stapley '36.

According to Symes and Chorley this mite has been recorded as injurious to mushrooms in Paris, but Jary and Stapley said that it did not injure mushrooms in England, though common in the beds.

H., species undetermined—Thomas '29, '31.

Probably *H. gracilipes* Banks. Found nearly immersed in the watery liquid on rotting mushrooms; probably secondary.

Pediculoides, n. sp.—Symes & Chorley '21.

Caused a slight dermatitis to men working on mushroom beds.

Gamasidæ (*Parasitidæ*)

Parasitus (*Gamasus*) *ancoriferus* Oudems.—Ripper '30.

Species of this genus are predacious on springtails and mites, and are sometimes very abundant in the compost piles and mushroom houses.

P. celer Koch and *P. fossorius* Berl.—Ripper '30.

Parasitus, undetermined species—Austin '33b.

"Observed attacking *Tyroglyphus mycophagus* Megn."

Gamasids, undetermined—Popenoe '12, '17, '25; Symes & Chorley '21; Thomas '31; Gahm '35.

Zschachia littoralis Oudms. and *Coproblaspis* sp.—Ripper '30.

Oribatidæ

Oppia (*Dameosoma*) *nitens* Koch—Ripper '30, '31; Austin & Jary '34; Bul. 34, Min. Agric. & Fisheries.

Ripper stated that this mite feeds on mushrooms near Vienna, but is not noticeably injurious.

Mites, undetermined species—Falconer '97; Duggar '04; Güssow & Odell '27.

HEXAPODA; Insects

Collembola: Springtails

Springtails are usually common, frequently very abundant, in mushroom houses, and generally are worse in the humid, even-temperatured conditions of caves and coal mines where mushrooms are sometimes grown. Here they feed on the growing mycelium and on the mushroom caps and stems. They frequently also cause much damage by eating all of the mycelium in the spawn pieces, necessitating replanting. Some species are very strongly positively phototropic, gathering in immense numbers in groups or piles in the mushroom house aisles soon after the manure has cooled in the beds. Springtails are among the major pests of mushrooms.

Achorutes (*Hypogastrura*) *armatus* Nic. and variety *inermis* Axels.—Popenoe '12, '17, '25; Folsom '16, '33; Headlee '16; MacNamara '19a; Symes & Chorley '21; Theobald '29; Thomas '29, '31, '34, '35; Ripper '30; Austin '33a; Austin & Jary '34, '35; Gahm '32a, '35; Jary & Austin '35, '37; Compton '36, Swan '37.

This is the common so-called "Mushroom Springtail," although in Pennsylvania it is generally less destructive than some *Isotoma* and *Lepidocyrtus* species. It is found throughout the world, and is apparently a bad pest in England. The injury

consists in feeding on the mycelium and chewing holes into the cap and stem surfaces, sometimes honeycombing the mushrooms.

A. (H.)maturus Folsom '33; Davis '35.

According to Davis, this species injures mushrooms in the caves at Leeds, Missouri.

A. (H.) manubrialis Tullb. and variety *assimilis* Krausbauer—Ripper '30; Stapel '32.

Very destructive to mushrooms in Austria. Ripper gives details of biology, ecology, etc. (Listed as a synonym of *A. armatum.*

A. cyanocephalus Nic., *A. rufescens* Nic., and *A. purpurescens* Lubbock.

Reported as damaging mushrooms in England—Symes & Chorley '21.

Achorutes, species undetermined—Buller '09.

"Infested *Stropharia semiglobata* and some other species of *Agaracinæ,* feeding on the spores; also on the fruiting bodies of *Polyporus squamosus.*"

Onychiurus ambulans Nic.—Ripper '30.

Schöttella sp.—Gahm '29, '30b, d, '32a, '35; Thomas '31.

Lepidocyrtus cyaneus Tullb. and variety *cinereus* Fols.—Thomas '26, '29, '31, '34; Ripper '30; Gahm '32a, '35; Folsom '33; Davis '35.

Attacks mycelium and mushrooms. Sometimes very abundant.

L. lanuginosus (Gmel.)—Davis '35, '35a; Davis and Young '34, '35; Thomas '34; Davis & Claborn '35.

More destructive in Ohio and western Pennsylvania, where it occasionally causes much damage by honeycombing the mushrooms. Although found in eastern Pennsylvania, this large reddish species is seldom very injurious here.

L. albicans Reut.—Davis '35.

Heteromurus nitidus Templ. and *Tomocerus vulgaris* Tullb.—Ripper '30.

Proisotoma thermophila Axels.—Thomas '34.

Det. by J. W. Folsom. Injures spawn pieces and mycelium in Pa.

P. simplex Folsom—Davis '35.

"Attacking spawn, Capitol Heights, Md."

P. minuta Tullb.—Thomas '29; Ripper '30; Austin '33a; Davis '35.

"Damaging spawn, Arlington Farm, Va."

Isotoma immersa Fols.—Folsom '28.

"In enormous numbers in a mushroom cellar in New York State, according to Lintner."

Isotoma, species undetermined—Thomas '31; Gahm '32a, '35.

The species of *Isotoma* and *Proisotoma* sometimes destroy the mycelium in the newly planted spawn pieces.

Cyphoderus albinus Nic.—Ripper '30.

Entomobrya multifasciata (Tullb.)—Folsom '33.

"Eats fungus spores."

Sinella höfti Schäf.—Folsom '33; Davis '35.

Davis reported commercial damage to mushrooms at Leeds, Mo.

S. cæca Schott.—Speyer '33.

Xenylla humicola (Fab.)—Folsom '33; Davis '35; Davis & Claborn '35.

Folsom stated that this species was often injurious to mushrooms. Davis reported it from Kennett Square, Pa.

X. welchi Fols.—Folsom '16; Davis '35.

Attacks spawn and mushrooms, especially in the west.

X. mucronata Ax.—Speyer '33; Jary & Austin '37.

Sminthurus luteus Lubb.—Walton '17.

"On field mushrooms in England."

Hemiptera

Triphleps (*Orius*) *insidiosus* Say—Thomas '31.

Predacious on springtails. Only occasional in mushroom houses.

Dermaptera

Labia minor L.—Thomas.

Occasional in mushroom houses. Although it has been found in large numbers in the manure in mushroom beds on several occasions, it is not known to damage the mycelium or the mushrooms.

Orthoptera

Pristoceuthophilus pacificus Thom.—Camel Cricket—Popenoe '12, '17, '25.

Reported as eating into the caps of cultivated mushrooms on the Pacific coast.

Ceuthophilus uhleri Scudder—Cave Cricket—Haseman '33 correspondence.

"Does considerable damage to mushrooms in cellars."

Crickets, undetermined species—Davis '35a.

Periplaneta americana L.—American Roach—Busck 1902.

This is usually not injurious to mushrooms.

Coleoptera

Hydrophilidæ

Cercyon hæmorrhoidalis Fab., *C. quisquiluis* L. and *Sphæridium bipustulatum* Fab. are listed by Ripper '30 as being found in mushroom houses.

Staphylinidæ

Staphylinid beetles are found in mushroom houses in varying numbers, sometimes very abundantly. Usually they are feeding on springtails and other small animal life there, but there is some indication that some of the smaller species may occasionally cause injury by feeding on the growing mushrooms, eating out the interior of the smaller buttons. They may be secondary to other agencies which have started decay in the mushrooms.

Proteinus ovalis Steph.—Austin '33b.

"Possibly a predator; found in mushrooms attacked by other agencies, in England."

Quedius fulgidus Fab.—Thomas.

One of the more common larger Staphylinids found in mushroom houses. Feeds on springtails, fly larvæ, etc.

Oxyporus femoralis Grav. and *O. major* Grav.—Thomas.

Collected inside *Pleurotus* sp. in woods, Kennett Square, Pa. Have not been found in mushroom houses.

Tachinus fimbriatus Grav.—In same *Pleurotus*—Thomas.

Trichophya pilicornis Gyll.—Mushroom Cave, Luray, Va.—Reported by E. A. Chapin, U. S. National Museum.

Atheta arenicola Thoms.—Ripper '30.

A. virginica Brnh.—Davis '35.

"Extremely common in mushroom houses, Arlington Farm, Va., and throughout the mushroom growing district of Pennsylvania, Delaware, and New Jersey. Predacious, attacking the larvæ of the mushroom flies (*Sciara*) in the beds." The writer has also found this beetle feeding on *Tarsonemus* mites on mushroom beds at Kennett Square, Pa.

Philonthus sp.—Ripper '30.

Ptiliidæ (*Trichopterygidæ*)

Ptilium sp.—Davis '35.

"Reared from spawn from a house at West Chester, Pa." The writer has also found this minute beetle abundant in a mushroom house at Toughkenamon, Pa.

Ptenidium pusillatum Gyll.—F. C. Wood, Corresp.

"Pest in a mushroom house at Charlwood, Surrey, England."

Acratrichis sp.—Ripper '30.

Nephanes sp.—Davis '35.

"Feeding on spawn, Kennett Square, Pa."

Histeridæ

Hister bimaculatus L.—Thomas.

Occasional in mushroom houses. Not known to cause injury.

Acritus sp.—Davis '35.

"Predacious on springtails and mites, Arlington Farm, Va."

Atholus duodecimstriatus Schr.—Ripper '30.

Saprinus lautus Er.—Calwer '16.

"In faulendem Agaricus."

Anthicidæ

Tomoderus constrictus (Say)—Thomas '31.

Frequent in Pennsylvania mushroom houses, where it is predacious on springtails, etc.

Elateridæ

Melanotus sp.—Thomas.

Larvæ of this genus have been found feeding in fungi in woodlands, and on two occasions the writer has found several boring up through mushroom stems in mushroom houses. These larvæ

were probably brought into the houses with the casing soil taken from sod lands, where they are normal inhabitants.

Dermestidæ

Dermestes cadaverinus Fab.—Strong '22.

Intercepted in California in dried mushrooms from China.

Cryptophagidæ

Cryptophagus distinguentus—Ripper '30.

Mycetophagidæ

Litargus sp.—Thomas '34; Davis '35.

Usually not common. Eats small holes in caps and stems. Davis states in 1936 correspondence that *L. balteatus* Lec. is the species found in mushroom beds at Arlington Farm, Virginia. The writer has found it injuring cultivated mushrooms at Hershey, Pa., and West Chester, Pa.

Lathridiidæ

Corticaria serrata Payk.—Davis '35.

"Common on and about beds at Arlington Farm, Va. May feed on spawn."

Coccinellidæ

Halyzia sedecimguttata L., *Vibidia duodecimguttata* Poda, and *Thea vigintiduopunctata* L. (all Tribe Psylloborinii)—Strouhal '26.

"Feed on fungi injurious to plants, but are not very beneficial, and may help to spread these fungi."

Scarabæidæ

Aphodius fimetarius L.—Ritzema-Bos '17; Ripper '30; Thomas '34.

Although occasionally found in mushroom caves in the United States, it is not a pest here. According to Ritzema-Bos, however, this species is a well known mushroom pest in France, feeding on both mycelium and mushrooms.

A. ater DeG.—Ritzema-Bos '17.

Oxyomus sylvestris Scop.—Ripper '30.

Geotrupes stercorosus Scriba (*sylvaticus* Panz)—Zwölfer '35.

"Observed in 1934 attacking the stems and caps of young healthy edible mushrooms, *Boletus edulis* (Bull.) Fr. in South Germany. About ten per cent of these mushrooms were unfit for consumption."

Lepidoptera

Noctuidæ

Metalestra quadrisignata Wkr.—Thomas '31.

This looper caterpillar enters the mushroom house with the casing soil, and sometimes eats large holes in the caps and stems. Fortunately it feeds only a short time, then pupates. It is not common in mushroom houses.

Pyralidiidæ

Pyralis farinalis L.—Davis '35.

Reared from mushroom beds, Arlington Farm, Virginia.

Bombycidæ

Diacrisia (*Spilosoma*) *congrua* Walk.—Beutenmüller 1890.

"Attacks mushrooms but is rare. Parkville and West Farm, N. Y."

Tinæidæ

Tinea cloacella Haw.—Krause '16.

"Larvæ attacked dried mushrooms in Germany."

Lepidopterous larvæ, not identified—Austin '33b; Strong '21.

Strong reported these larvæ infesting mushrooms in England.

Diptera

Chironomidæ

Forcipomyia cilipes Coq.—Thomas '34.

The larvæ of this fly are sometimes found in small scattered groups in the manure of the beds, feeding on the mycelium. Never common enough to be really injurious, however.

Mycetophilidæ

A number of species of the genus *Sciara* occur in mushroom houses, usually one or two species being represented in each house. Of these, some are quite rare. *Sciara multiseta* Felt,

S. coprophila Lint. and *Neosciara pauciseta* Felt are the most common and most injurious species in Pennsylvania. Their injury is to the spawn pieces, to the growing mycelium, and to the interior of the growing mushrooms, ruining the latter. They enter the houses with the manure, and are also attracted in by the odor of the growing mycelium.

Austin and Pitcher '36b have recently described the hypopygia and other characters differentiating the males of *S. agraria* Felt, *S. auripila* Winn., *S. vivida* Winn., *S. umbratica* Zett. and *S. fenestralis* Zett.

Sciara larvæ have a chitinous black head capsule, differentiating them from the larvæ of Phorid flies, which have no head capsule, but which cause similar injury to mushrooms. Several Sciarid species found in mushrooms outdoors have not yet been found injuring artificially grown mushrooms.

Sciara agraria Felt—Felt 1896 (original description); Popenoe '12, '17, '25; Theobald '27, '28a, '29; Thomas '31; Austin '33a; Austin & Jary '34, '35; A. & Pitcher '36b.

S. præcox Meig.—Symes & Chorley '21; Theobald '27, '28a; Ripper '30.

According to Theobald, and to Symes & Chorley, this is one of the worst mushroom pests in Britain.

S. auripila Winn.—Speyer '27, '33; Austin '33a; A. & Jary '34; A. & Pitcher '36b.

S. coprophila Lint.—Lintner '94 (orig. description); Falconer '97; Johannsen '12; Thomas '29, '31.

S. multiseta Felt—Felt '96 (orig. descr.); Smith '08; Johannsen '12; Popenoe '12, '17, '25; Thomas '31.

S. vivida Winn.—Austin '33a; A. & Jary '34; A. & Pitcher '36b.

S. umbratica Zett.—Austin '33b; A. & Jary '34; A. & Pitcher '36b.

S. varians Johns.—Austin and Jary '37 describe the male genitalia; Jary and Austin '37 say it is not known to infest mushrooms.

S. fenestralis Zett.—Austin '33b; A. & Jary '33, '34, '35; Jary '34; A. & Pitcher '36a, b; Pitcher '36.

This species and *S. umbratica* were bred from mushrooms and also fed on the mycelium in the beds. Austin and Jary '33 give

considerable information on the biology and control experiments, while Pitcher '36, gives extensive life history and biology notes and larval instar measurements. Austin and Pitcher '36a give a method for rearing this and other Sciarids.

S. annulata Meig.—Theobald '28b, '29.

According to Austin and Jary '34, and Austin '33b, this species is probably the same as *S. umbratica* Zett.

S. frigida Wtz. and *S. ingenua* Duf.—Cause mushroom injury in Austria, according to Ripper '30.

Neosciara pauciseta Felt—Johannsen '12; Stewart '27; Thomas '29, '31.

N. sexdentata Petty—Munro '37.

Abundant in a greenhouse mushroom bed at Fargo, North Dakota.

Sciara, species undetermined—Smith 1894, '09; Güssow & Odell '27; Charles & Popenoe '28; Gahm '30, '32a, '35; Plant. i. Danmark '32; Stapel '32; Jary '34; Thomas '34; Davis & Young '34, '35; Davis '35a; Davis & Claborn '35; McCarthy '36; McDaniel '32.

Leia sp., *Exechia* sp., and *Mycetophila* sp.—Weiss '21.

According to Weiss, the larvæ of the last two are frequent in wild mushrooms and occasional in cultivated mushrooms.

Fungivora fungorum DeG.—Okada '36b.

The larvæ infest *Armillaria melea, Boletus elegans,* & *Pholiota* sp.

F. centralis Mats.—Okada '34.

The larvæ feed on mushrooms in Hokkaido.

Bolitophila disjuncta Lw.—Okada '35, '36a.

This species prefers *Armillaria mellea* (Vahl.) Fr. and sometimes *Hypholoma sublateritium* (Schaeff.) Fr.

B. maculipennis Wlk.—Okada '35.

This attacks *Pholiota nameko.*

Bolitophilella cinerea Mg.—Okada '35, '36a.

Prefers *Pholiota* species, but feeds on a wide range of fungi.

B. japonica Okada—Okada '35.

Attacks *Pholiota* and *Hypholoma* species. Most of these fungi are soft and sticky on the surface, and these insects seem to select them for their physical characters.

Cecidomyiidæ

Mycophila (Pezomyia) speyeri Barnes—Barnes '26, '27, '28, '29; Speyer '26, '27; Austin '34; Austin & Jary '34; Anderson '36.

Barnes stated that the larvæ feed on mycelium. According to Anderson, Dr. Mathias Thomsen reared this species from larvæ found in decaying mushrooms at Gentofta, Denmark.

M. fungicola Felt—Felt '11a, b; Barnes '27; Anderson '36.

Reared from larvæ from young mushrooms collected in Cal. in '97.

Miastor sp.—Theobald '28a; Barnes '28; Ripper '30.

Taken from the gills of mushrooms and spawn in England. The larvæ are pædogenetic, giving rise to living young.

Cecidomyiid larvæ, unidentified—Austin '33b; Gahm '32a; Thomas '31.

Undetermined Cecid larvæ are occasionally found in immense numbers on the casing soil and on the mushrooms, where they mine the outside tissues, giving the mushroom a yellowish, slimy appearance. They also feed on the mycelium in the beds.

Lestodiplosis sp.—Felt '32, correspondence; Thomas '34.

According to Felt, these larvæ are predacious on mites.

Scatopsidæ

Rhegmoclemma atrata Say—Thomas '34.

A few larvæ feeding on mycelium, Kennett Square, Pa., 1934.

Scatopse fuscipes Meigen-infests *Armillaria matsutake* in Japan and Korea, according to Okada '38.

Phoridæ

The small active Phorid flies are frequently very abundant in mushroom houses. The larvæ feed on the newly-planted spawn-pieces and on the mycelium. Later, during the warm weather of spring they render the interior of the pinheads and larger mushrooms spongy and unfit for market. The first four species in the following list are those usually found in Pennsylvania mushroom houses. They enter the houses with the manure, or through the doors and ventilators after the crop has started.

They are normal inhabitants of the composting mushroom piles outdoors. The flies have been found to carry the spores of several of the mushroom diseases.

Megaselida (*Aphiochæta*) *albidihalteris* Felt—Felt 1896, original description; Malloch '12; Popenoe '12, '17, '25; Ripper '30; Thomas '31; Plant. i. Danmark '33; Stapel '32; Austin '33a, '34; Austin & Jary '34; Jary '34; Davis '35a.

Bred from *Agaricus campestris* and from *Coprinus comatus.* This is the most common Phorid enemy of mushrooms in England.

M. iriquoiana Malloch—Davis '34; Davis & Young '34. Kennett Square, Pa.

M. agarici Lint.—Lintner 1894, orig. description; Falconer '97; Malloch '12; Thomas '31.

Bred from *Agaricus campestris, Coprinus comatus,* and *Agaricus subrufescens* Peck.

M. minuta Lint.—Lintner '94; Falconer '97; Duggar '04.

According to Lintner, Dr. L. O. Howard reported this injuring mushrooms at Colora, Md.

M. aletiæ Comstock—Thomas.

Reared from undetermined fungus, Kennett Square, Pa., Sept. '29. Det. by C. T. Greene.

M. smithii Brues—Malloch '12, orig. descript.

Bred from *Agaricus* sp. in New Jersey.

M. straminea Malloch—Malloch '12, orig. desc.

"Reared from fungi by Popenoe."

M. cayuga Malloch—Malloch '12.

Bred from *Lepiota procera* in Maryland.

M. scalaris Loew—Thomas.

Bred from *Lepiota* sp. in woods. Kennett Square, Pa. Det. Greene.

M. pygmæa Zett.—Davis '35, California; Thomas '31, Pa.

M. lutea Meig., *M. flava* Fall, *M. nigra* Meig., *M. pumila* Meig.

All noted in *Agaricus prunulus* Fries. in Europe by Schiner, 1864.

M. bovistæ Gimmerth—bred from *Lycoperdon bovista*—Schiner '64.

M. projecta Becker—In fungi, Europe—Malloch '12.
M. cinerella Lundb.—Plant. i. Danmark '33.
M. matsutakei Sasaki—Sasaki '35, orig. descr.
Attacks the edible *Armillaria matsudake.*

Platypezidæ

Platypeza minorata Banks—Thomas '29.
Sometimes very abundant and destructive to field *Agaricus* in southern Pennsylvania and northern Delaware, though I have never found them in mushroom houses. Det. by E. T. Cresson, Jr.

Borboridæ

Leptocera (*Limosina*) *ferruginata* Stenh.—Austin '33b, '34.
"Taken from composted manure piles and from established beds."
L. heteroneura Hal.—Austin '37a.
Emerged in June from mushrooms infested with larvæ of Phorids and other Diptera.

Ortalidæ

Chrysomyza demandata Fab.—Thomas.
In immense numbers in one mushroom house before the bearing season, occasionally in other houses, Kennett Square, Pa. Not known to be a mushroom pest. Det. by J. M. Aldrich, U. S. Nat. Mus.

Drosophilidæ

Drosophila larvæ are occasionally found in mushroom houses in warm weather, especially in the spring, but usually attack only decaying or injured mushrooms, especially those affected with Mycogone and similar diseases, which they may help to spread. Several undetermined drosophilid species have also been reared from wild *Agaricus* and other fungi in meadows and woods.
Leucophenga varia Wlk.—Thomas '29.
Leucophenga, sp. undetermined—Thomas '29.
These two *Leucophenga* species were reared from decaying mushrooms in house at end of bearing season.
Drosophila funebris F.—Austin '33, '34.

Anthomyiidæ

Muscina assimilis Fall.—Keilin '17.

The larvæ are frequently found in decaying fungi, where they feed on such Dipterous larvæ as *Drosophila confusa, Fannia canalicularis* L. and *Aphiochæta rufipes* Mg.

Hymenoptera

Braconidæ: Alysiinæ

Aspilota concolor Nees—Austin '33a, '34.

Emerged from the pupæ of Phorids, *Megaselia albidihalteris* Felt.

Phænocarpa psalliotæ sp. n.—Telenga '35.

Reared from Dipterous larvæ in mushrooms in Germany.

Proctotrupidæ

Calliceras (*Ceraphron*) *ampla* Ashmead—Thomas '29, '31.

This is a parasite of Sciarids in Pennsylvania, but is apparently very local and not effective in control. Determined by A. B. Gahan.

Exallonyx ligatus Nees—Austin '33b.

"Found with *Sciara* larvæ, but not common. May be a predator."

Diapriidæ

Synacra brachialis Nees—Austin '33a.

"Probably a parasite of Dipterous larvæ in mushroom houses."

VERTEBRATA

REPTILIA: Chelonia: Turtles

Cistudo carolina (L.)—Box Turtle.

This turtle has occasionally been found feeding on wild mushrooms and other fungi in meadows and woodlands.

MAMMALIA

Muridæ: Mice and Rats

Mus musculus L.—House Mouse.

Mus norvegicus Erx.—Norway or Gray Rat.

These two widespread rodents are frequently quite injurious

in mushroom houses, where they eat into the caps and dig up the beds, causing much annoyance to the growers.

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